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Novel space environment monitor, instrument, and space mission concepts

(Laboratory of Space Systems and Astronautics, RISH, Kyoto University)

Hiroshi Yamakawa, Hirotsugu Kojima, and Yoshikatsu Ueda

Space debris observation, modelling, and mitigation

The space debris problem is tackled from observation (space situational awareness), trajectory evolution, and mitigation points of view. 1) A method to identify the size, shape, and rotation features, and to determine the trajectory of known space debris using range Doppler data of MU (Middle and Upper) Radar, RISH, Kyoto Universiry, is investigated with successful observation results. 2) A study to investigate space debris trajectory evolution focusing on objects smaller than 1 cm has been started to shed light on geomagnetic field effects. 3) An on-orbit space debris observing system is studied assuming an optical sensor onboard a satellite. The required specifications of optical sensors and ranges of observable space debris are investigated for application to removal sequence.

Electromagnetic space propulsion systems

Recently, new propulsion systems that utilize electromagnetic forces acting on a charged spacecraft were proposed. The Lorentz force that acts when a charged object goes across the Earth's magnetic field and the Coulomb force that acts on among the charged objects can be employed to control the orbit of charged spacecraft or space debris by controlling the electrostatic potential of the object with charged particle emitters. One of our studies is to evaluate feasibility and performance of such "electromagnetic orbital control" regarding both orbital dynamics and plasma physics by using numerical simulation on the super computer system of Kyoto University. We 1) proposed a new charging model that enables to compute the surface potential fast and precisely by considering a velocity distribution of emitted particles, 2) proposed a new secondary electron emission model for particle simulations that can simulate much like the actual physics than conventional methods, and 3) revealed the thrust performance of an electric solar wind sail, a novel propulsion system which obtains its thrust by deflecting the ions in solar wind with numerous positively charged tethers.

Miniaturization of plasma wave receiver system

Plasma wave receiver is one of the essential instruments for space environment exploration; however, conventional receiver has a problem in its large weight and size. In order to overcome this problem, we have been miniaturized plasma wave receiver by developing Application-Specific Integrated Circuits (ASIC) for plasma wave receivers. We succeeded in developing miniaturized plasma wave receiver by realizing analog circuit, which is especially large part of the receiver, using ASIC. This miniaturized receiver will be onboard the SS-520-3 sounding rocket, which will launch in the not-too-distant future to resolve the cause of ion outflow phenomena at the cusp region. In addition, we aim to develop a mixed-signal ASIC chip for one-chip plasma wave receiver. The mixed-signal ASIC chip includes all analog and digital circuits for plasma wave receiver. One-chip plasma wave receiver allows to reduce weight and size of the instruments drastically, and it will contribute for increasing opportunities of plasma wave observation.

Theoretical study of fine bubble and its application research

Fine bubble (FB, less than 1 micro meter) technology is standardized as ISO/TC 281 and its basic and application research is conducted by many researchers. Basic properties and assumed generation mechanisms are now making clear. There is still remained problems of integrated theory of FB such as generation and stabilization. And we also need to apply FB technology to various application field with its detailed theory. As for integrating basic properties, we conduct various measurement such as ultrasonic attenuation of FB water, as measuring electrical potential of FB and as comparison with nano-particles in water. We also try to do application experiment in agricultural field as international collaboration study.